

# Development of ductile Cr-Re alloys for high temperature application in aggressive atmosphere

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Mechanical, chemical and thermal shock properties  
Results overview

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## EADS Corporate Research



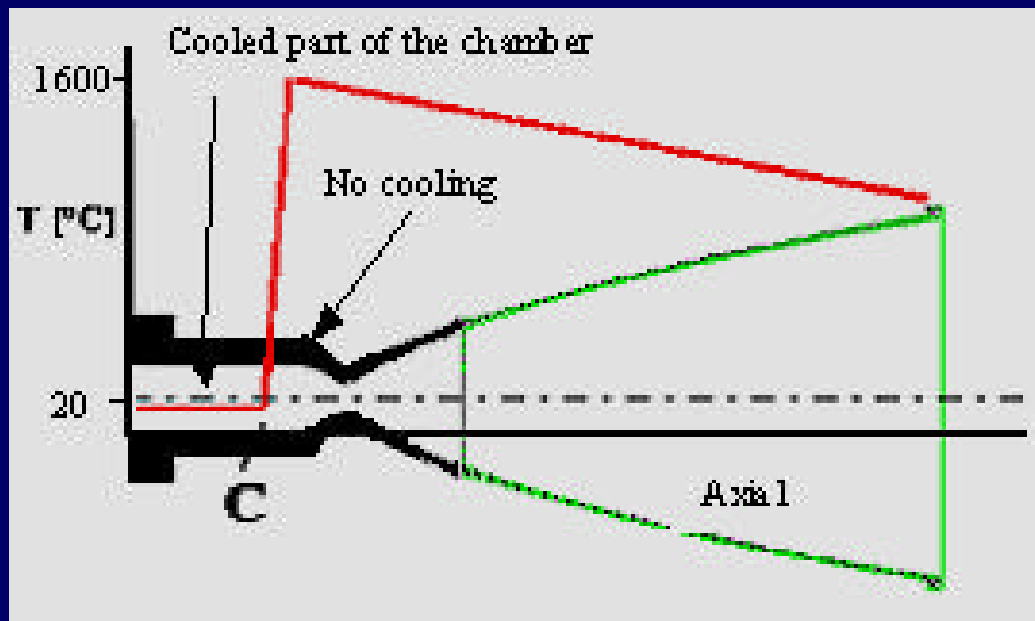
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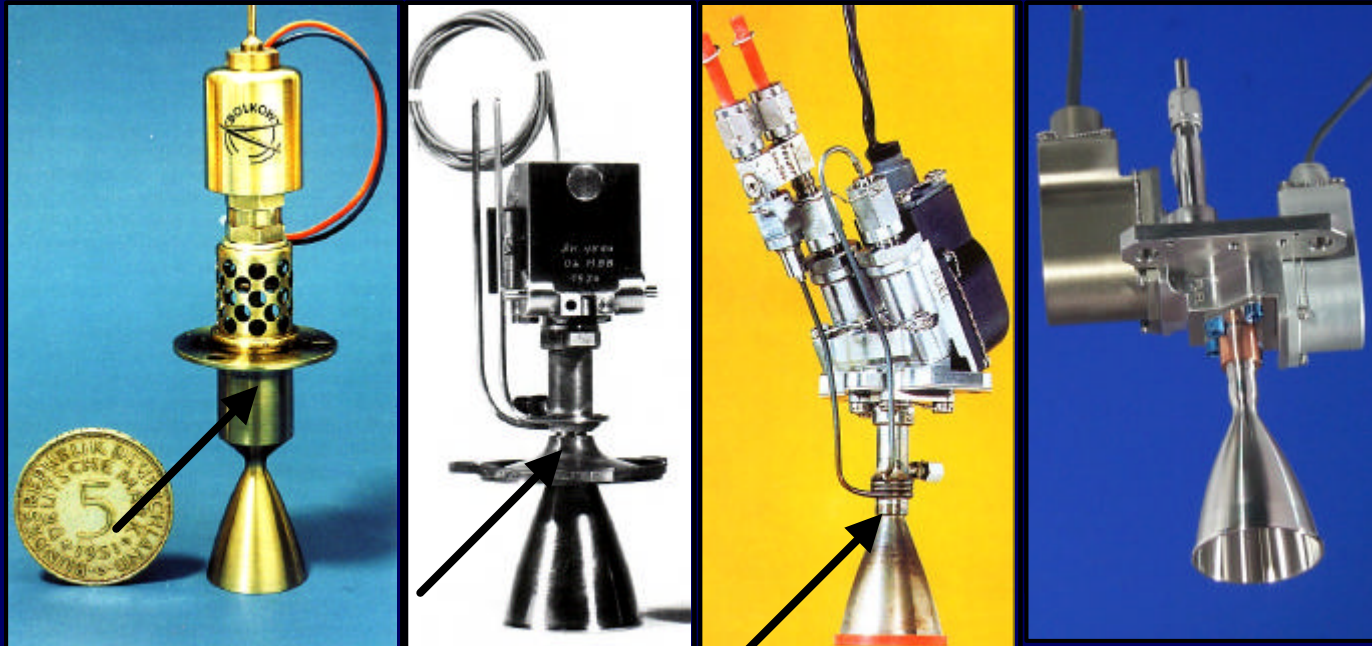
## Satellite thruster combustion chambers

Hydrazine based propellants:

- $\text{HNO}_3$  atmosphere at more than 1500 °C
  - 40 at % free nitrogen
  - 2 at % free oxygen
- Longitudinal temperature gradient of 500 K/mm
- Heating kinetics of 500 K/s (700 cycles)



## Materials history



**1960**  
**Cobalt base**  
**800 °C**

**1970**  
**Nickel base**  
**1000 °C**

**1990**  
**Platinum base**  
**1700 °C**

## Investigated / Qualified materials



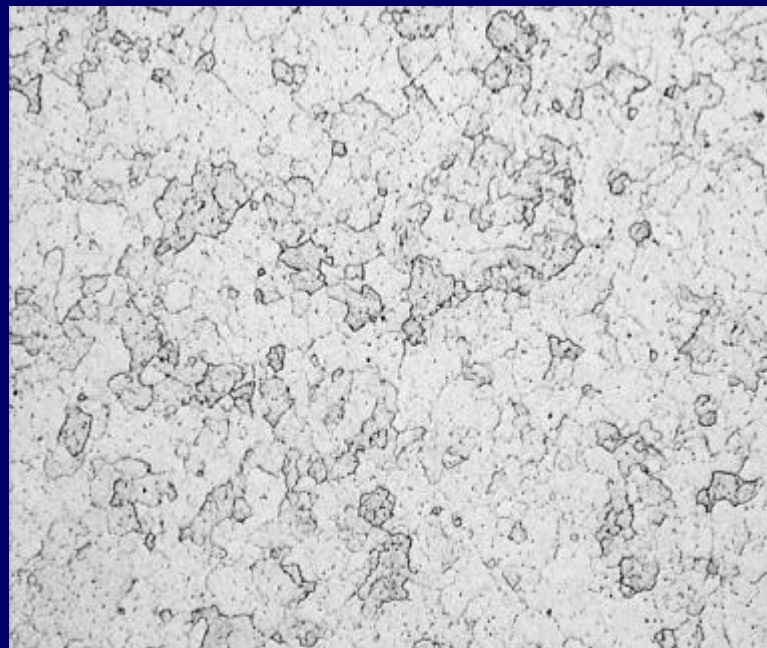
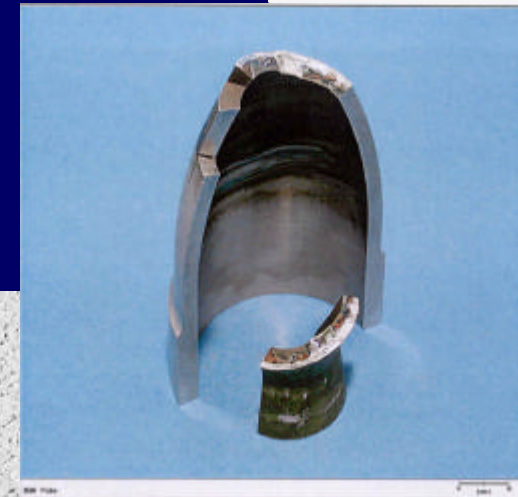
- Qualified materials
    - : Nb coated with quartz
    - : Re coated with Ir
  - Materials under qualification
    - : Re coated with Ir (PM)
    - : Ta/W coated with Re/Ir
  - Previous experience at EADS
    - : Ta/W coated with  $\text{Al}_2\text{O}_3$
- No coating needed
- : Pt based alloys, (qualified)
  - : Cr based alloys



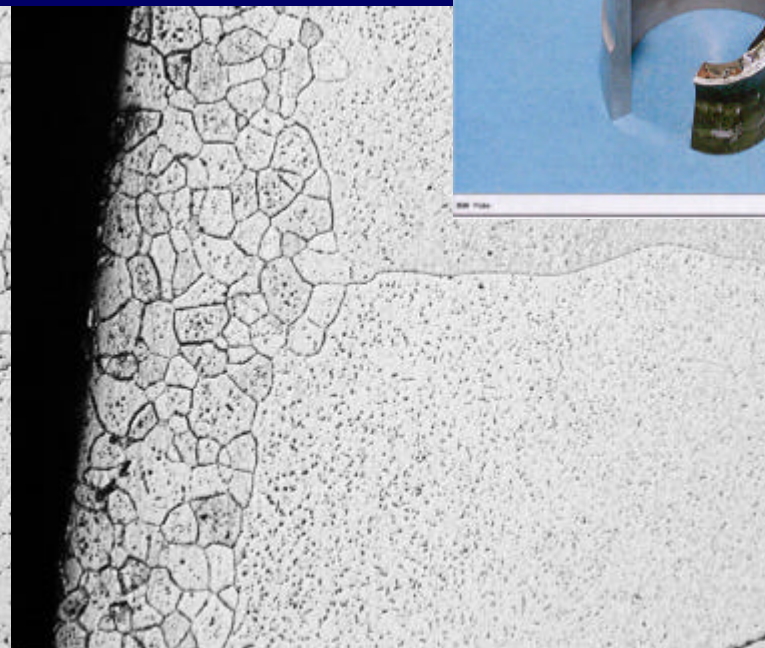
## EADS experience with Cr based alloys

Firing experiences (1500 °C) in 1992

- Brittle fracture due to excessively high DBTT
- Microstructural instability at high T (Rec / GG)



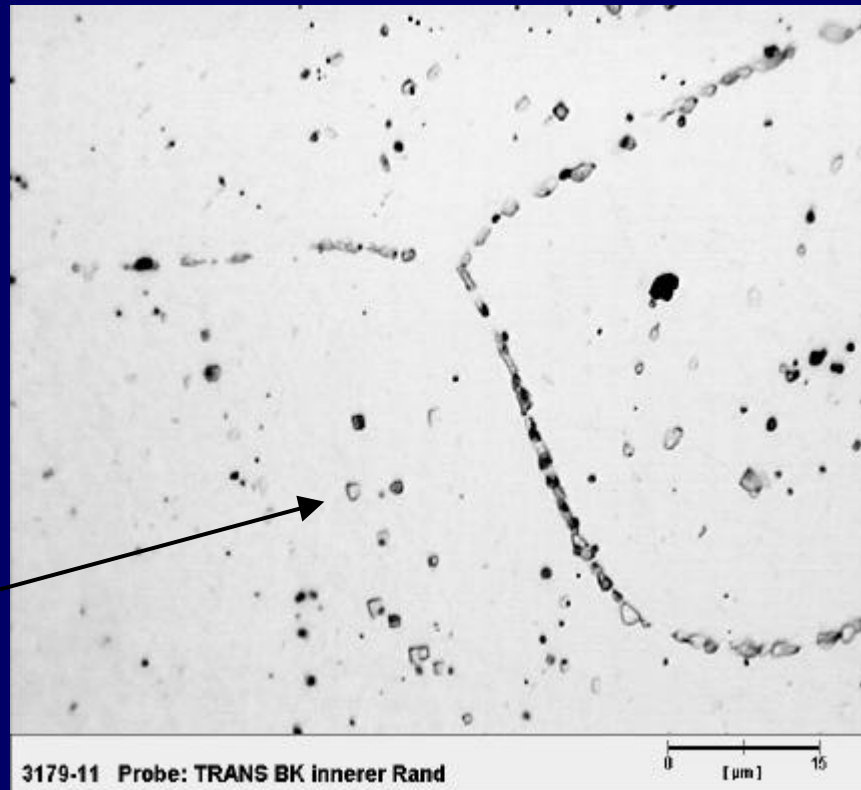
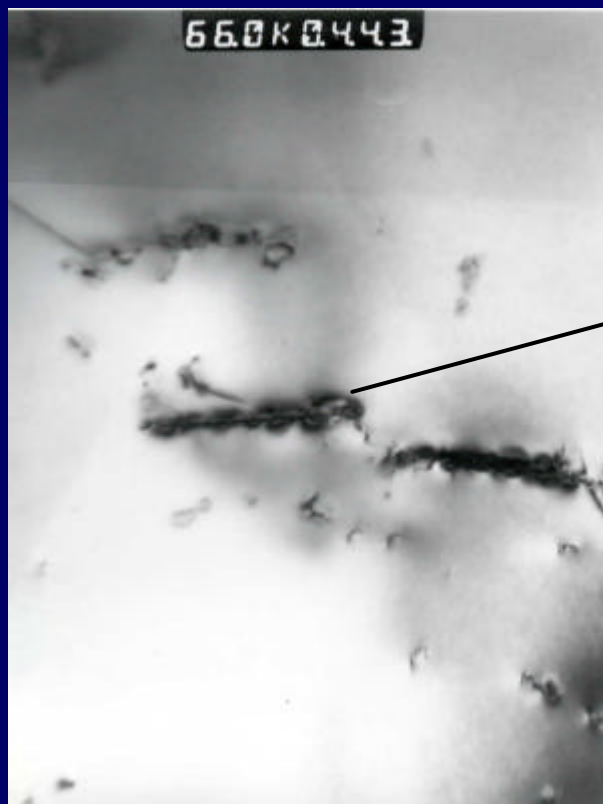
3181-6 Probe: TRANS ROHR Mitte



3179-6 Probe: TRANS BK äußerer Rand

## Chemical instability

Precipitation of a second phase in grain boundaries and internal defects

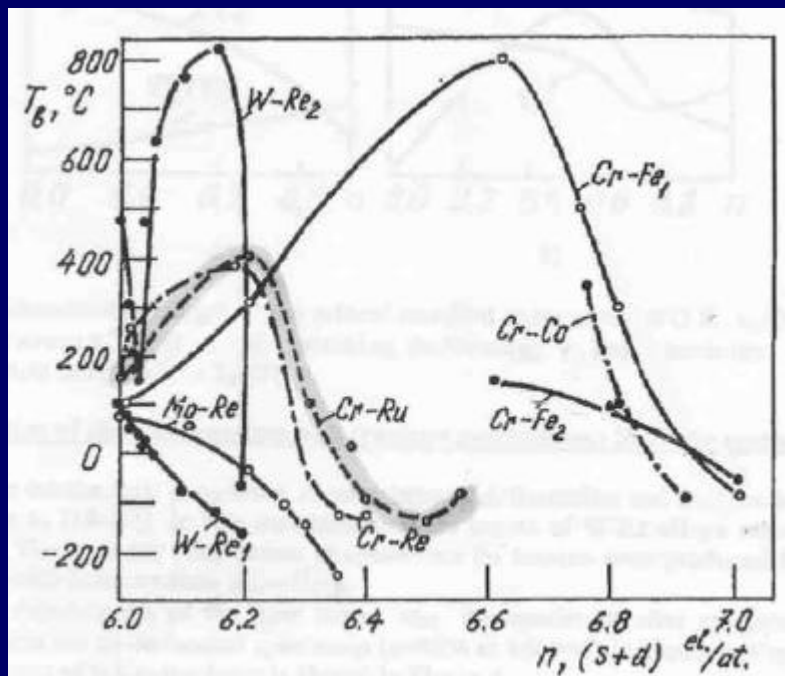


	C	H	O	N
Before	7	2	35	53
After	9	2,5	87	145



## The Re effect on BCC refractory metals

- Three Re effects:
  - I Increase of low temperature ductility and strength (VIA)
  - II Increase of the strain hardening rate (VIA)
  - III Increase high temperature strength and creep resistance
- Case of Cr : Increase of recrystallisation T and melting point



No database on the properties of the alloys

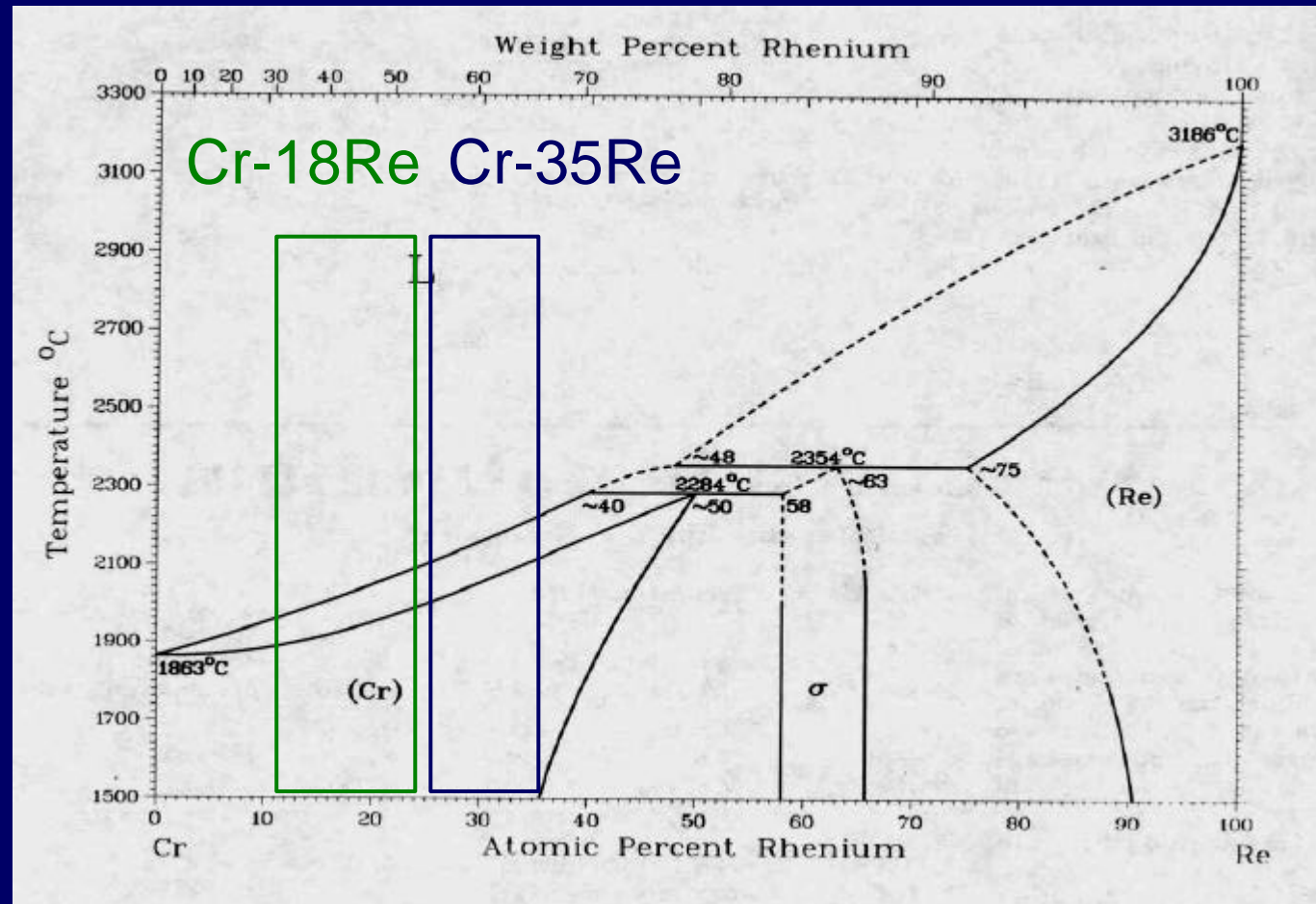
Mechanical  
Chemical  
Thermal

Thermal shock  
Particular properties

## Systematic study of Cr-Re solid solution alloys

- Selection of a tailored Cr-Re alloy for satellite thruster combustion chambers
  - Manufacturing method
  - Mechanical properties (cryogenic up to 1800 °C)
  - Oxidation/nitridation resistance (up to 1600 °C)
  - Thermoshock and thermal gradient to 500 K/s; 500 K/mm
  - Thermal properties (up to 1600°C)
  - Joining and welding
  - Resistance to propellant
  - Thermomechanical fatigue

## The demonstration alloys



## Manufacturing method

Powder Metallurgy

VS

Ingot Metallurgy

- Short to mid term: Ingot Metallurgy
  - Prototype alloys by Arc Melting
  - Production by Induction Melting and casting
- Mid to long term: Powder Metallurgy

## Arc molten alloys

